CLAIMS

We claim:

1. A miniature endoscope comprising:

an optical waveguide that transmits an image, the waveguide having a diameter of less than 2 mm, and having a light absorbing layer;

an optical element coupled to a distal end of the waveguide;

an optical relay that is optically coupled to a proximal end of the waveguide; and

an imaging device mounted at a proximal end of the optical relay that receives an image from the optical waveguide.

2. The miniature endoscope of Claim 1 wherein the endoscope has an outer diameter of 1.6 mm or less.

3. The miniature endoscope of Claim 1 wherein the waveguide has an outer diameter between 0.6 and 1.6 mm.

4. The miniature endoscope of Claim 1 wherein the endoscope further comprises an illumination channel and a binary phase ring which disperses light from the illumination channel.

5. The miniature endoscope of Claim 1 wherein the waveguide comprises a glass having a refractive index in the range between 1.6 and 1.9.

6. The miniature endoscope of Claim 1 wherein the waveguide comprises a glass rod.

7. The miniature endoscope of Claim 1 wherein the light absorbing sheath comprises a thickness between 5 and 10 μm.

8. The miniature endoscope of Claim 1 wherein the light absorbing sheath comprises extramural absorption glass.

9. The miniature endoscope of Claim 1 wherein the light absorbing sheath comprises a refractive index of 1.6 or less.

10. The miniature endoscope of Claim 4 wherein the illumination channel has a wall thickness in a range of 0.1 mm and 0.2 mm.

11. The miniature endoscope of Claim 4 wherein the illumination channel has a refractive index in a range between 1.4 and 1.6.

12. The miniature endoscope of Claim 1 wherein the illumination channel further comprises an outer sheath.

13. The miniature endoscope of Claim 12 wherein the outer sheath comprises a polyamide coating.

14. The miniature endoscope of Claim 13 wherein the polyamide coating has a thickness between 100 and 150 μm.

15. The miniature endoscope of Claim 1 wherein the optical element comprises one or more lenses.

16. The miniature endoscope of Claim 1 wherein the optical element comprises a plastic lens.

17. The miniature endoscope of Claim 1 wherein the imaging device comprises a charge coupled device.

18. The miniature endoscope of Claim 1 wherein the endoscope further comprises a distal needle that penetrates tissue.

19. The miniature endoscope of Claim 1 wherein the optical element has a rectangular cross-sectional area.

20. The miniature endoscope of Claim 1 wherein the waveguide has a rectangular cross-sectional area.

21. The miniature endoscope of Claim 1 wherein the optical relay has a rectangular cross-sectional area.

22. The miniature endoscope of Claim 1 further comprising a handle in which the optical relay and imaging device are positioned.

23. The miniature endoscope of Claim 22 further comprising an illumination channel that is optically coupled to a light source in the handle.

24. The miniature endoscope of Claim 22 further comprising a coupler that connects the handle to the optical waveguide.

25. The miniature endoscope of Claim 22 further comprising a disposable sheath that extends over the handle.

26. The miniature endoscope of Claim 25 wherein the sheath is attached to a rigid waveguide housing that is connected to the handle.

27. The miniature endoscope of Claim 1 further comprising a light source that is optically coupled to the optical waveguide.

28. A miniature endoscope comprising:

an imaging channel having a diameter less than 2 mm, and a light absorbing layer defining a channel boundary;

an illumination channel having a first layer on a inner surface of the illumination channel and a second layer on an outer surface of the illumination channel;

an optical element coupled to a distal end of the imaging channel;

an optical relay coupled to a proximal end of the imaging channel; and

an imaging device coupled to a proximal end of the optical relay.

29. The miniature endoscope of Claim 28 wherein the imaging device comprises a charge coupled device.

30. The miniature endoscope of Claim 28 wherein the imaging channel comprises a transparent material having a refractive index of at least 1.6.

31. The miniature endoscope of Claim 30 wherein the imaging light channel comprises a glass rod.

32. The miniature endoscope of Claim 31 wherein the glass rod comprises an F2 or an F7 glass.

33. The miniature endoscope of Claim 28 wherein the light absorbing layer comprises a light absorbing glass.

34. The miniature endoscope of Claim 33 wherein the light absorbing layer comprises a B6-2 glass or a BG-4 glass.

35. The miniature endoscope of Claim 28 wherein the illumination channel is coupled to a light source.

36. The miniature endoscope of Claim 28 wherein the illumination channel comprises a material having a refractive index higher than the first layer and the second layer.

37. The miniature endoscope of Claim 28 wherein the illumination channel comprises a transparent material having a refractive index of at least 1.6.

38. The miniature endoscope of Claim 28 wherein the first layer and the second layer each have index of refraction of less than 1.6.

39. The miniature endoscope of Claim 28 wherein the endoscope has a handle and a rigid channel having connected to the handle with a coupler.

40. The miniature endoscope of Claim 28 wherein the optical element has a rectangular cross-sectional area.

41. The miniature endoscope of Claim 28 wherein the imaging channel has a rectangular cross-sectional area.

42. The miniature endoscope of Claim 28 wherein the optical relay has a rectangular cross-sectional area.

43. A method of forming a reflective boundary on a glass channel for a microendoscope comprising the steps:

providing a glass channel for a microendoscope;

providing a light absorbing material;

extruding the light absorbing material over the glass channel to form a reflective boundary on the glass channel.

44. The method of Claim 43 further comprising the step of using a fiber optic drawing process to extrude the light absorbing material over the glass channel.

45. The method of Claim 43 further comprising the step of using a bar-in-tube drawing process to extrude the light absorbing material over the glass channel.

46. A method of forming an image light channel for a microendoscope comprising the steps:

providing an illumination channel having a refractive index;

coating an inner surface and an outer surface of the illumination channel with a material having a refractive index lower than the illumination channel refractive index;

providing an image light channel for a microendoscope; and

attaching the illumination channel to the image light channel.

47. The method of Claim 46 further comprising the step of using a tube-extrusion process for form the coatings on the illumination channel.

48. The method of Claim 46 further comprising the step of depositing a glass on the outer surface and the inner surface of the illumination channel.

49. The method of Claim 46 further comprising the step of using a bar-in-tube fiber drawing process to fuse the illumination channel to the image light channel.

50. A method of forming a cladding structure on an image light channel for a microendoscope comprising the steps:

providing an image light channel;

forming a material having an index of refraction on the image light channel that is lower than the index of refraction of the image light channel to form a first cladding;

extruding an illumination channel over the first cladding on the image light channel; and

forming a second cladding on the illumination channel.

51. A miniature endoscope comprising:

a handle having an imaging device, a light source and a first coupling element;

a rigid probe having a waveguide and a second coupling element that connects the probe to the first coupling element, the waveguide having a light absorbing boundary.

52. The endoscope of Claim 51 further comprising:

a beamsplitter mounted within the housing wherein the beamsplitter directs light from the lighting source through a rod and lens assembly to an object such that the beamsplitter receives light from an object through the rod and lens assembly and directs the light to the imaging device.

53. The endoscope of Claim 51 wherein the waveguide comprises a hollow channel.

54. The miniature endoscope of Claim 51 wherein the imaging device comprises a plurality of lenses and a polarizer.

55. The miniature endoscope of Claim 54 wherein the polarizer comprises a sheet polarizer.

56. The miniature endoscope of Claim 54 wherein the polarizer comprises a cross polarizer.

57. The miniature endoscope of Claim 56 wherein the cross polarizer comprises a first prism and a second prism.

58. The miniature endoscope of Claim 51 wherein the light source is coupled to a polarizer and a lens.

59. The miniature endoscope of Claim 51 wherein the light source is coupled to an illumination channel with a fiber optic element.

60. The miniature endoscope of Claim 51 wherein the probe comprises an annular illumination channel around the waveguide.

61. The miniature endoscope of Claim 51 wherein the light source comprises an external lamp.

62. The miniature endoscope of Claim 61 wherein the external lamp comprises a xenon light source.

63. The miniature endoscope of Claim 51 wherein the endoscope further comprises a sheath attached to the probe and extending over the handle.

64. The miniature endoscope of Claim 53 wherein the sheath comprises a sterile barrier.

65. The miniature endoscope of Claim 51 wherein the probe comprises a needle with a distal optical system.

66. The miniature endoscope of Claim 51 further comprising a cannula wherein the probe fits within the cannula.

67. The miniature endoscope of Claim 51 wherein waveguide comprises a rod and lens assembly having a locking mechanism wherein the cannula locks onto the rod and lens assembly.

68. The miniature endoscope of Claim 66 wherein the cannula comprises an illumination channel.

69. The miniature endoscope of Claim 66 wherein the cannula further comprises a stylet.

70. A method of using a miniature endoscope comprising:

providing a base unit and a sheath assembly having a probe waveguide and a sterile barrier; and

attaching the sheath assembly to the base unit such that the sterile barrier extends over the base unit.

71. The method of Claim 70 further comprising providing a cannula and securing the cannula to the sheath assembly.

72. The method of Claim 70 further comprising providing a luer fitting on the sheath assembly.

73. The method of Claim 70 further comprising disposing of the sheath assembly after use and attaching a second sheath assembly to the base unit for further use.

74. The method of Claim 70 further comprising providing a probe waveguide having a hollow channel and a light absorbing channel wall.

75. The method of Claim 70 further comprising providing a base unit including a handle, an imaging device within the handle and a relay optical system that couples an image from the waveguide to the imaging device.

76. The method of Claim 70 further comprising providing a probe waveguide having a diameter of 2 mm or less.

77. The method of Claim 70 further comprising connecting the base unit to a display.

78. The method of Claim 70 further comprising providing an annular illumination channel in the probe.

79. The method of Claim 70 further comprising providing a probe waveguide having a length between 2 cm and 10 cm.

80. The method of Claim 70 further comprising directing polarized light through the waveguide.